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National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Purchasing Office
Huntsville, Alabama 35812

Attention: PR-EC

Gentlemen:

This is the eleventh progress report for Contract No. NAS8-5324, "Exploratory Studies and Analysis of the Problem of Buckling of Cylindrical Shells with Inclined Stiffeners," covering the period 16 October through 15 December, 1964.

During the period covered by this report the critical value of P, the transverse load at the end of the inclined-stiffened cylindrical shell, was investigated. When the cylinder was not very short, the deflection function was assumed to be

$$w = b_1 + b_2 \cos\left(\frac{x_2}{2R}\right) \cos\frac{mx_1}{L} \cos\frac{nx_2}{R}$$

$$+ b_5 \left(\frac{x_1}{L}\right) \cos\left(\frac{x_2}{2R}\right) \cos\frac{mx_1}{L} \cos\frac{nx_2}{R}$$

The total energy in the shell and stiffeners was first found. Approximations were made by assuming m^2 and n to be much greater than unity. Two equations were obtained from minimization of the total energy with respect to b_2 and b_5. The condition of nontrivial solution of b_2 and b_5 establishes the following equation

$$\bar{P}^2 + \left(\frac{c_1}{\beta} + c_2\beta\right)\bar{P} + \left(\frac{c_3}{\beta^2} + c_4 + c_5\beta^2\right) = 0$$

where c_1, c_2, c_3, c_4 and c_5 are parameters depending on m, n and the properties of shell and stiffeners. The parameter β is equal to R/m^2t. The nondimensional load $\bar{P}$ is defined as

$$\bar{P} = \frac{PL}{\pi ERt^2}$$

For the unstiffened shell,

$$\bar{P} = (6 - \sqrt{12})\,\phi$$

The minimum value of ϕ is found at

$$\beta = \beta_o = \frac{\left(\frac{R^2}{L^2} + \frac{n^2}{m^2}\right)^2}{2\sqrt{3(1-\nu^2)}\left(\frac{R}{L}\right)^2}$$ and

$$\bar{P}_o = \frac{(6-\sqrt{12})}{\sqrt{3(1-\nu^2)}}$$

where $\overline{P}_o$ represents the critical value of $\overline{P}$ on the unstiffened shell. Numerical calculations were made on stiffened shells, using $\overline{E}\ \overline{I}\,\overline{l} = 2$ and $\beta = \beta_o$. The results are tabulated. Some of them are shown in Figs. 1 and 2. It can be observed that the optimum angle of inclination of stiffeners is 45^o.

Sincerely yours,

S. Y. Lu

S. Y. Lu
Associate Research Professor

NOTATIONS

E, E_k	=	Young's modulus of cylinder and stiffeners, respectively
R	=	radius of middle surface of cylinder
t	=	thickness of cylinder
L	=	length of cylinder
ℓ	=	total length of stiffeners
I_k	=	moment of inertia of stiffeners
G_k, I_k	=	polar moment of inertia and shear modulus of stiffeners, respectively
$\bar{E}$	=	E_k/E
$\bar{I}$	=	$I_k/\pi R t^3$
$\bar{\ell}$	=	ℓ/L
k^2	=	$G_k\ I_k\ /E_k\ I_k$
γ	=	angle between the stiffeners and the generator of the cylinder

TABLE I

($k^2 = 3/4$, $R/L = 1/3$)*

γ	0° (Stringers only)			30°			45°				
n/m	0	1	∞	0	1	∞	0	1/2	1	2	∞
$\overline{P}$	15.1	3.22	1.56	10.4	5.29	4.61	8.3	7.83	7.18	7.36	8.3

γ	60°			90° (rings only)			0° - 90° (Stringers-rings)		
n/m	0	1	∞	0	1	∞	0	1	∞
$\overline{P}$	3.99	8.24	8.4	1.56	1.54	1.64	8.33	4.43	1.67

* $\overline{P}$ is independent of R/L when $n/m \rightarrow 0$ or ∞.

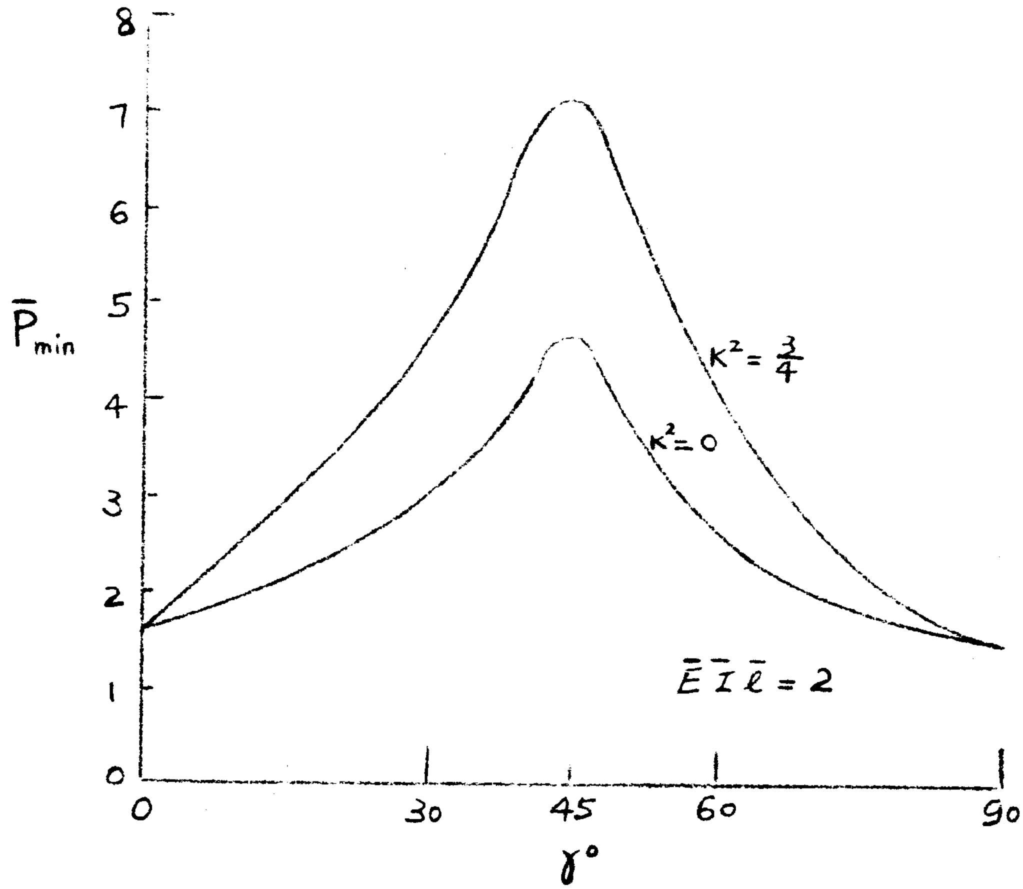
8
7
6
5
$\bar{P}_{min}$
4
3
2
1
0
$K^2 = \frac{3}{4}$
$K^2 = 0$
$\bar{E}\,\bar{I}\,\bar{\ell} = 2$
0
30
45
60
90
$\gamma°$

Fig. 1

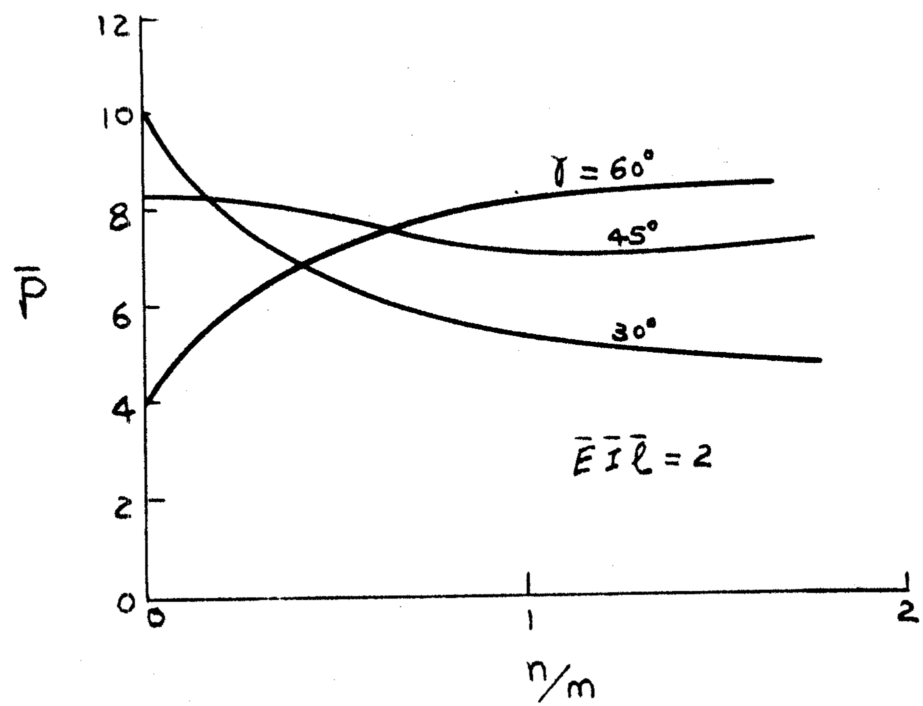

Fig. 2